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(54) FLEXIBLE HOSE OF HIGH PRESSURE-BEARING CAPABILITY AND PROCESS FOR THE PRODUCTION THEREOF

(71) We, MŰANYAGIPARI KUTATÓ INTÉZET, a body corporate organized under the laws of Hungary, of 114, Hungária körút, Budapest XIV., Hungary, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to a flexible hose of high pressure-bearing capability. Further, the invention relates to a process for the production of such hose.

The term "hose of high pressure-bearing capability" refers to a flexible hose exposed not only to very high intrinsic pressures, amounting often to several hundred atmospheres, but also simultaneously or separately to external pressures of similar orders of magnitude.

Up to the present, hoses of this type have been produced as follows: wires of various thicknesses, cross-sections and materials, mostly of a metal, steel or aluminium, shaped as continuous spirals, were placed on an inner flexible, liquid- and gas-tight layer denoted as "breather". These wires were arranged on the hose at various pitches, their task being to take up the external and instrinsic as well as the radial and axial force effects to which the hoses are exposed.

A great number of procedures of the transfer and shaping of the reinforcing wires are known. In one type of embodiment the radial force effects are taken up by an element shaped as a spiral spring of large cross-section and low pitch (from 1 to 10°). The cross-section can be chosen arbitrarily though the secondary moment must be high enough to eliminate the hazard of indentation caused by the external pressure. In this type of arrangement the axial force effects are taken up by wires with a high pitch, e.g. from 60 to 90°, of a cross-section smaller than in the preceding case, and of a high strength, located near each other in a parallel or in a criss-crossed way.

In another type of arrangement the reinforcing wires are located all at the same angle; in that case every reinforcing wire participates in the accommodation of radial and axial loads. In case of high inner intrinsic pressures the winding angle at this type of arrangement is about 54°.

The external surface of the hoses is coated generally by a flexible wear-resistant layer.

The flexible hoses of high pressure-bearing capability known up to the present have a rather large weight per running metre; e.g. a hose resistant to an over-pressure of 400 atm, and of a diameter of 150 mm weighs about 50 kp/m. Since these hoses are used in many fields of application, e.g. in oil extraction in a vertical position, it is extremely important to reduce the load caused by their own weight. The major part of the own weight of the hoses is caused by the weight of the reinforcing wires.

One of the ways of reducing the hose weight is the use of light-weight materials, e.g. of plastics reinforced with glass fibres or graphite fibres (particularly of polyester or epoxy resins) for the preparation of the spiral-shaped reinforcing inserts instead of metal wires. On using such plastics, tensile strengths of from 80 to 120 kp./sq.mm. and moduli of elasticity of from 1500 to 2500 kp./sq.mm. can be attained at a specific gravity of 1.2-1.8 kp/dm^3. These values make possible the replacement of the reinforcing inserts of metal and of the metal wires, respectively, of the flexible hose of high pressure-bearing capability, from plastics reinforced with glass fibre. This can be carried out relatively easily in cases when the reinforcing elements are exposed

solely to tensile forces.

In case of an external pressure, however, structural elements of an extreme high rigidity are needed, and the geometrical shape and elasticity moduli of the reinforcing strands are of decisive importance. In hose systems where the radial force effects are taken up by a wire of low pitch and large cross-section, the shaping of these structural elements from plastics reinforced by glass fibre is impeded by technological and dimensioning difficulties. On the one hand, it is difficult to produce spiral shapes from plastics reinforced by glass fibre and, on the other hand, the spiral shape is not the best one from the aspect of the created force effects because on the action of external forces of torsional moment occurs in the material and on the effect of intrinsic pressures relatively large deformations appear.

The invention is aimed at producing a flexible hose of high pressure-bearing capability where the radial force effects are taken up by plastics elements reinforced with glass fibre or with other high-strength fibres, such as graphite fibres, whereas the axial force effects are taken up in the known way by metal wires or by plastics wires reinforced with glass fibre, arranged at a high pitch. A further aim of the invention is to mechanize to the greatest extent possible the production of hoses according to the invention.

The invention is based on the recognition that closed circular rings can resist optimally external and internal radial force effects. At the same time it is possible in the easiest way to produce, from plastics reinforced with glass fibre, a high-strength product containing large amounts of fibre-glass, by winding them into ring-shaped bodies. Thus, accordingly no heavy, spiral-shaped, inner reinforcing metal structure of low pitch is needed in the hose. Instead, a light circular ring-shaped wound plastics element of any desired cross-section, of high fibreglass content and thus of high strength can be applied which elements can be placed close to each other in the inner sleeve of the hose, in order to secure maximum radial rigidity and at the same time also flexibility of the hose.

Accordingly the invention provides a flexible hose of high pressure-bearing capability, having a fluid-tight flexible inner sleeve, on the external surface of which stiffening plastics rings reinforced with fibres are arranged beside and/or overlapping each other, said rings being able to take up the external and internal radial force effects to which the hose is exposed.

According to a preferred embodiment of the invention the stiffening rings are made of two different materials, the radially inner edge and one or both side edges of each ring consisting of a prefabricated thermoplastic resin, whereas the interior of each ring consists of a reinforced thermosetting resin which in rigid with the prefabricated thermo-plastic resin.

The stiffening rings are preferably arranged in circumferential grooves formed on the inner sleeve of the hose, said grooves being perpendicular to the longitudinal axis of the hose.

Further the invention provides a process for producing hoses as specified above, wherein stiffening rings of desired size and shape are produced by winding on an inner support of continuous fibre reinforced plastics material preferably polyester or epoxy resin, then pulling the rings on to the outer side of an inner fluid-tight sleeve of the flexible hose, whereafter other required layers of the hose are built in the desired form onto the inner sleeve provided with the stiffening rings.

According to a preferred embodiment of the process of the invention the ring-shaped elements are prepared from a thermoplastic resin, then a reinforced thermosetting resin is applied by winding the latter onto said ring-shaped elements which eventually form the radially inner edge and one or both side edges of the final stiffening rings, the said reinforced thermosetting resin is cured on the surface of the said ring-shaped elements, and the cured rings are threaded onto the inner sleeve.

Another preferred embodiment of the process according to the invention consists in forming circumferential grooves in the inner sleeve of the flexible hose, preferably by cutting, sticking, pressure moulding or injection moulding, then winding fibre reinforced plastics into the grooves and subsequently curing this reinforced plastics.

According to another preferred embodiment of the invention a continuous reinforced plastics layer is transferred by winding onto the inner sleeve of the hose the said layer is cured on the sleeve, thereafter the cured reinforced plastics layer is cut circumferentially up to the inner sleeve, said circumferential cuts being made at distances corresponding to the desired width of the stiffening rings, to form a series of reinforced plastics rings which are mechanically independent of each other but are arranged beside each other.

The accompanying drawings serve to illustrate in detail the following description, given by way of example, of preferred embodiments of the invention. In the drawings:

Fig. 1 is a longitudinal section of the hose according to a preferred embodiment

of the invention, showing an advantageous arrangement of stiffening rings on an inner fluid-tight sleeve;

Fig. 2 represents some advantageous embodiments of the reinforcing rings embodied in the invention.

Fig. 3 shows stiffening rings reinforced with fibreglass and arranged in a mould consisting of a material differing from that of the ring, said mould embracing the ring at three sides and being retained on the ring;

Fig. 4 shows an embodiment of the hose according to another preferred embodiment of the invention where the reinforcing rings are located in ring-shaped grooves formed in the inner fluid-tight sleeve; and

Fig. 5 shows a method of cutting rings on an inner sleeve provided with a reinforced plastics coating.

According to a preferred embodiment of the invention, one proceeds as follows: A reinforcing material of glass fibres or of other suitable fibres is impregnated with a plastics impregnant and transferred by winding to a ring-shaped tool on which the plastics is cured. The rings 1 produced in this way are then pulled the desired distances onto the inner sleeve 2 of the flexible hose. Subsequently the hose is built-up in the usual manner, i.e. the axial reinforcing fibres and further elastic layers are transferred consecutively on to the inner sleeve provided with the stiffening rings.

In order to attain adequate flexibility of the hose equipped with rings, it is preferable to form the lateral surfaces of the rings so that the rings have a slightly conical sectional shape, as shown in Fig. 1, so that bending of the hose is not inhibited by the rings.

The stiffening rings prefabricated from plastics reinforced with glass fibre may have various shapes. Some expedient shapes are shown in Fig. 2. The simplest form has a frusto-conical cross-section as shown in Fig. 2*a*. A ring of rhomboidal cross-section is shown in Fig. 2*b*, this shape offering the advantage that any possibly occurring uneven radial deformations are compensated by the overlapping rings. Fig. 2*c* shows a Z-shaped cross-section which has an aim similar to that of the embodiment disclosed in Fig. 2*b*. In the embodiment according to Fig. 2*d* the part of the rings in the contact with the inner sleeve is rounded, in order to prevent any lesion of the inner sleeve by the rings when the hose is moved vigorously. In the embodiment according to Fig. 2*e* the stiffening rings are pulled over each other in two or more rows so that they partially overlap to resist extraordinarly high pressures. According to Fig. 2*f* in turn, both sides of the rings are bordered by part-spherical surfaces ensuring maximum flexibility for the structure.

The rings are arranged on the inner fluid-tight sleeve so closely to each other than the material of the inner sleeve cannot be deformed to a detrimental extent by the internal pressure acting through the slits between the individual rings.

Another expedient way of making the rings is as follows. A ring-shaped element or former 3 (Figure 3) is prefabricated, preferably by injection moulding. The glass fibre reinforced plastics 1 is applied onto this element 3 by winding and cured in this position to form rings. The element 3 is then rigid with the cured reinforced plastics, the element 3 forming the radially inner edge and both side edges of the completed ring. The element 3 may alternatively form only one of the side edges of the completed ring. The rings are then placed on the flexible inner sleeve. This method has the advantage that, on one hand, no metal tools are needed for producing the rings and, on the other hand, the rings in contact with each other on the flexible hose may in many cases be less exposed to wear effects created by the movement of the hose. The mentioned shaped former elements bordering the rings can be made expediently of a wear-resistant thermoplastic resin, e.g. a polyamide.

A hose may also be produced by preparing the stiffening plastics rings, instead of by prefabrication, directly on the hose by winding. One of the variants of this method is to cut circumferential grooves in the inner sleeve of the hose, as shown in Fig. 4, winding glass fibre reinforced plastics into these grooves, and curing the plastics in the wound state. In this case it is expedient to keep the hose under internal pressure to prevent its deformation during winding. The grooves can be formed also by shaping fins from the material of the sleeve or by drawing, bonding or injection moulding finned rings onto the sleeve.

Another way of producing rings on the inner sleeve is by continuously winding as shown in Fig. 5, a coherent layer of plastics reinforced with glass fibre (5 in Fig. 5) at a low winding angle (80° to 90°) on the inner sleeve 2, curing this layer on the inner sleeve, then circumferentially cutting this cured layer into annular shapes by means of a cutting device (6 in Fig. 5), expediently equipped with a rotary-disk shaped blade so that the cutting disk should cut only the plastics coating reinforced with glass fibre, without intruding into the inner sleeve. Thus, a previously rigid hose of plastics reinforced with glass

fibre and having on its inner surface an elastic sleeve, can subsequently be converted into a flexible hose.

The flexible hose according to the invention and its method of production are further illustrated with the aid of the following non-limiting Examples.

Example 1

Glass roving containing 12,000 elementary fibres is drawn through a bath prepared from a mixture of polyester resin of moderate reactivity and benzoyl peroxide catalyst. The desired glass content of 65% is adjusted by drawing the roving through a control slit. Rings of an inner diameter of 100 mm and of an external diameter of 112 mm are produced by winding the glass fibres impregnated in this way. The width of these rings is 6 mm at the inner diameter and 5.7 mm at the external diameter. The rings are cured by heat treatment, then they are placed closely to each other and pulled on to a hose of 99 mm external diameter and 3 mm wall thickness, extruded from polyamide. An axial reinforcing system prepared from wires of plastics reinforced with glass fibre, of 4 mm diameter and of a circular cross-section, is built-up in a way known in hose manufacture, and also an external, wear-resistant rubber layer is applied as a coating, similarly in a known way.

A hose produced in this way resists to an inner over-pressure of 800 atm and to an external overpressure of 300 atm, its weight being 12 kp. per running metre.

Example 2

Rings of 0.5 mm wall thickness, consisting of a cylindrical central part and two sides (as in Fig. 3), are produced by injection moulding from polyamide. The inner dimensions of the ring-shaped elements produced in this way are: 80 mm inner diameter, 5 mm inner width and 5 mm thickness. Glass fibres impregnated in the way as described in Example 1 are transferred by winding into the grooves of the polyamide rings so that the grooves are completely filled up. Then the plastics material is cured at a temperature of 80°C on the element of polyamide. The stiffening rings produced in this way, the inner surface and both lateral surfaces of which are coated with a 0.5 mm thick layer of polyamide, are pulled in a way similar to that described in Example 1 on to a flexible sleeve of 78.5 mm external diameter, and the complete hose is built up further according to Example 1 or in the usual way known in the art.

Example 3

A hose of 200 mm external diameter and 4 mm wall thickness is extruded from soft polyvinyl chloride. Immediately after the extrusion of the hose, rings of 1 mm width and 10 mm height prepared from soft polyvinyl chloride are bonded at distances of 10 mm onto the external surface of the hose. Subsequently, continuous glass fibre containing 40% by weight of epoxy resin is introduced by winding into the slits between the rings. Then the glass fibre reinforced plastics wound around the hose is cured at a temperature of 45°C, and the axial reinforcing fibres and the external wear-resistant coating are built up on the cured plastics in the desired manner.

Example 4

A hose of 120 mm external diameter and 5 mm wall thickness extruded from synthetic rubber. After the extrusion, a 8 mm thick coherent layer of glass fibre reinforced plastics is continuously transferred onto the hose at a winding angle of 90°, and in a continuous operation the plastics is cured on the synthetic rubber hose. The applied plastics and glass fibre are the same as those specified in Example 1. The rigid hose produced in this way is then led through a cutting device having a 0.8 mm thick rotary disk containing diamond grains. This rotary disk is rotating also around the hose and thus cuts the plastics layer reinforced with glass fibre in its entire thickness. This circular cut is performed in 10 mm distances, obtaining in this way rings of 9 mm width each, at distances of 1 mm from each other on the flexible inner sleeve of synthetic rubber. The complete building up of the hose is carried out in a known way.

WHAT WE CLAIM IS:

1. A flexible hose of high pressure-bearing capability, having a fluid tight flexible inner sleeve, on the external surface of which stiffening plastics rings reinforced with fibres are arranged beside and/or overlapping each other, said rings being able to take up the external and internal radial force effects to which the hose is exposed.

2. A flexible hose as claimed in claim 1, wherein the stiffening rings are made of glass fibre reinforced plastics material.

3. A flexible hose as claimed in claim 1, wherein the stiffening rings are made of two different materials, the radially inner edge and one or both side edges of each ring consisting of a prefabricated thermoplastic resin, whereas the interior of each ring consists of a reinforced thermosetting resin which is rigid with the prefabricated thermoplastic resin.

4. A flexible hose as claimed in claim 1, wherein the stiffening rings are arranged in circumferential grooves formed on the inner sleeve of the hose, said grooves being perpendicular to the longitudinal axis of the hose.

5. A process for producing a flexible

hose of high pressure bearing-capability as claimed in claim 1, comprising the steps of producing stiffening rings of desired size and shape by winding on an inner support of continuous fibre reinforced plastics material, then pulling the said stiffening rings onto the outer side of an inner fluid-tight sleeve of the said flexible hose, and thereafter building in a known way the other required layers of the hose on the said inner sleeve provided with the said stiffening rings.

6. A process as claimed in claim 5, wherein the plastics reinforced with fibres is a member selected from the group consisting of polyester resin and epoxy resin.

7. A process as claimed in claim 5, in which ring-shaped elements are prepared from a thermoplastic resin, then a reinforced thermosetting resin is applied by winding the latter onto said ring-shaped elements which eventually form the radially inner edge and one or both side edges of the final stiffening rings, the said reinforced thermosetting resin is cured on the surface of the said ring-shaped elements, and the cured rings are threaded onto the inner sleeve.

8. A process as claimed in claim 7, in which the ring-shaped elements are prepared from a thermoplastic resin by injection moulding.

9. A process as claimed in claim 5, wherein circumferential grooves are formed in the inner sleeve of the flexible hose, then fibreglass-reinforced plastics is wound into the grooves and subsequently the reinforced plastics is cured.

10. A process as claimed in claim 9, in which the circumferential grooves are formed in the inner sleeve by cutting, bonding, pressure moulding or injection moulding.

11. A process as claimed in claim 5, wherein a continuous reinforced plastics layer is transferred by winding onto the inner sleeve of the hose, the said layer is cured on the sleeve thereafter the cured reinforced plastics layer is cut circumferentially up to the inner sleeve, said circumferential cuts being made at distances corresponding to the desired width of the stiffening rings, to form a series of reinforced plastics rings which are mechanically independent of each other but are arranged beside each other.

12. A flexible hose of high pressure-bearing capability substantially as herein described with reference to any one of the Examples.

13. A process as claimed in any of claims 5 to 11, substantially as herein described with reference to any one of the Examples.

14. A flexible hose of high pressure-bearing capability prepared by a process as claimed in any of claims 5 to 11 and 13.

15. A flexible hose according to claim 1 substantially as herein described with reference to and as shown in Fig. 1 of the accompanying drawings.

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1 488 975 COMPLETE SPECIFICATION
1 SHEET *This drawing is a reproduction of the Original on a reduced scale.*

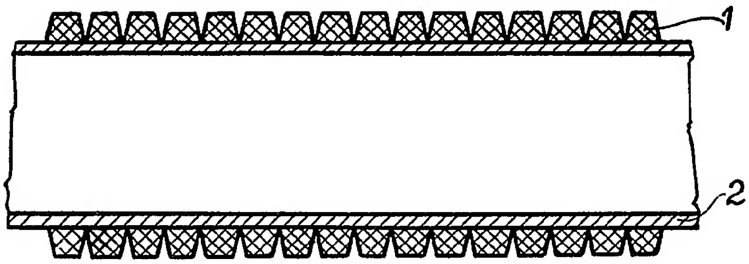

Fig.1

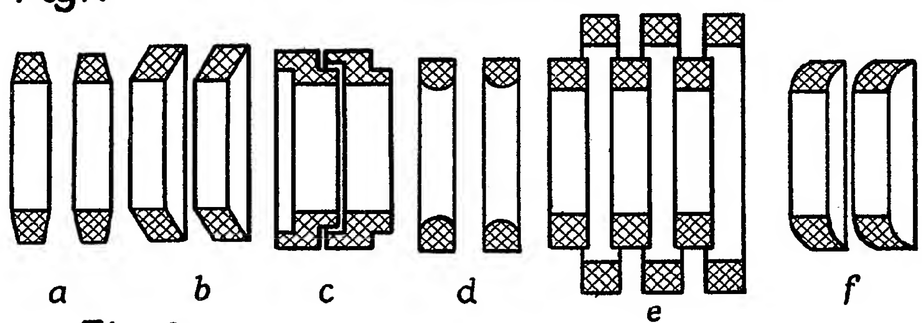

Fig.2

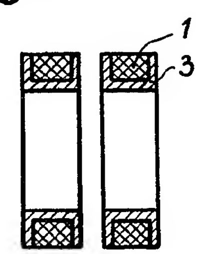

Fig.3

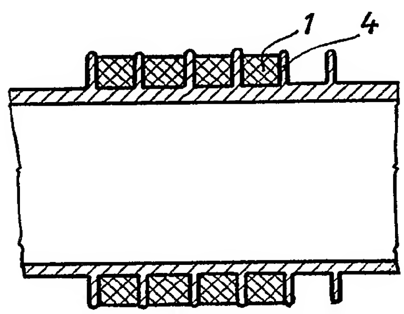

Fig. 4

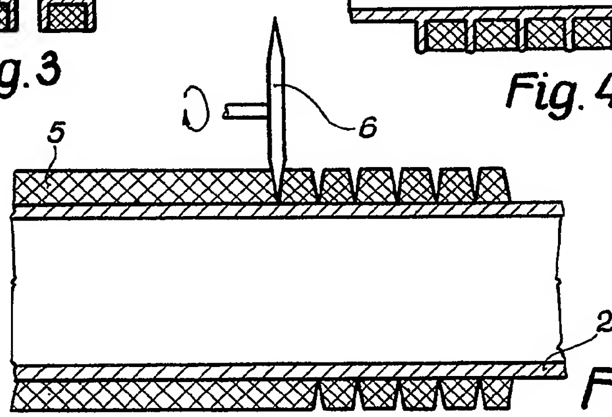

Fig.5